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PONTOON BRIDGES

An Economical, Though Much Neglected Type. Suitable for Both Fixed and Moving Spans.

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Pontoon bridges are not so often used for moving spans as are trusses with their greater rigidity under loads, and yet they may sometimes be quite satisfactory, especially for highway service.

Types

Floating bridges are capable of development in several directions, and the moving spans may be classified under the following headings:

(a) Those in which a floating span is drawn out from the line of roadway.

(b) Those which revolve about hinges at the shore end.

(c) Those which revolve on a centre buoy, the vertical axis of which does not change position.

The first includes all those, whether supported on barges or on separate pontoons, which are towed or otherwise drawn clear of the structure, examples being those over the Golden Horn, and across the Hooghly at Calcutta. It also includes those bridges with only a single platform, such as that over the canal at Dublin, which was a fixed bridge when in place, but which could be removed to open the channel.

The second class includes a large assortment of swings, revolving about pivots at their rear ends, and supported at the outer end on a barge or float, examples being those at Aalborg, and the temporary ones at Chicago. This class should also include those bridges with double leaves, such as the frame bridge over the Kaiser Wilhelm Canal and that at Nebraska City, Iowa, over the Missouri River.

The third class has rigid trusses with equal arms, supported at their centre on a floating buoy, which revolves inside a ring of guide piles, on top of which is a balance track which supports only enough load to hold it in position. This is illustrated by the bridges at Spencer Dock, and over the Weaver River at Northwich, England.

Movable pontoon bridges might also be classified according as they are supported on barges or on separate buoys or floats, and also as they are wholly or only partly floating.

Bridges which are supported throughout their fixed part on pontoons, may have opening spans of other types such as bascules or direct lifts, examples of hinged bascules being built about ten years ago in India, where double pontoons were used beneath the hinges or the somewhat similar one proposed a few years ago for Seattle.

Suitability of Movable Pontoon Bridges

These bridges are most suitable where the current is small and where ice can easily be broken. Their unsuitability in heavy ice was proven at Budapest between the years 1837-47, when a bridge was removed every winter, and for six months of every year, travel was taken over on the ice, involving heavy risk. They are appropriate on water with small change in elevation, but not for tidal basins. Scows covering a large water area, such as those used at McGregor and Reed's Landing, are better suited for railway service than individual buoys, which at Maxau would sustain only a light 18-ton locomotive. Mr. D. J. Whittemore, under whose direction several of these bridges were built, reported in 1884 that pontoon bridges with double leaves 500 feet long, making a total opening of 1000 feet, would be quite practicable and could be opened or closed in four minutes.

Provision for River Travel

The decks of pontoon bridges may be built up on trestle bents, high enough above the water to leave space under the platform and between the boats or pontoons for the passage of river craft, an example being the bridge at Calcutta over the Hooghly River, the deck of which is 27 feet above the water, Owing to established street grades, this is often impossible, as for example at Dublin over the Royal Canal, where the street is only 16 inches above the water.

Vertical adjustment of a railway track on a floating pontoon, to compensate for variations in water level, when the pontoon lies between trestle work or other approaches, the grade of which is at a fixed elevation, may be made by blocking up the track between side supports, as was done on the first bridge at McGregor. The track could in this way be maintained at a fixed level regardless of the rise or fall of water. In deciding upon a clear width for river travel, if the pontoon span revolves in the usual way about one corner, and when open, lies parallel to the stream, the width of the open channel will be decreased by the width of the barge, and provision must be made for this obstruction by making the opening and the barge just that much longer.

A method of clearing the floor before floating out the moving span, is illustrated in the Hooghly bridge where two sections of the platform, 20 feet long, one at each side of the moving span, are revolved over the adjoining roadway while being supported from beneath by hinged struts. In other cases, a simple floor apron can be

thrown back by hand, leaving the movable section free at each end.

Long bridges with very light travel, when only small funds are available for a bridge of any kind, may have their decks wide enough for only a single carriage track, and occasional extensions in the width where vehicles can pass. One or more lines of light chain can sometimes be used for railings where bascule or other movements would prevent the use of riveted or stiff sections.

Advantages and Disadvantages of Pontoon Bridges

The chief advantage of pontoon bridges is their economy in foundation over deep water, and the possibility of floating them away to another location when no longer needed at their original site. A disadvantage is that they are suitable only for comparatively low levels and cannot be opened quickly. The pontoons are liable to leak and settle in the water, and they are seriously affected by its rise and fall, by ice formation and river drift, and may sink more or less under heavy moving loads. In the following pages, examples are given of how some of these objections have been overcome.

The Pontoons

Floating military bridges, which had been used ever since the days of Cyrus, had boats or pontoons five to fifteen feet apart in the clear, supporting a platform ten to twelve feet wide made of plank on stringers, but pontoons for many old Roman bridges were of wicker work covered with hides. In succeeding centuries, the armies of other countries made their pontoons with wooden frames covered with plank, sheet copper, india rubber, or canvas, waterproofed with tar or paint. The Germans, in the seventeenth century, used timber pontoons covered with leather, and the Dutch, similar ones covered with tin, while the army of Napoleon preferred copper. For ease in transporting, they were sometimes made in two or more pieces which were fastened together before being launched. Recent ones have watertight compartments, so a single leak will not cause them to sink, and the platforms usually lie on trestles standing in the bottom of the floats. Floating piers have also been made of an assemblage of casks or logs lashed together, with sufficient buoyancy to sustain their loads, closed casks being floated on their sides and open ones on end. Empty barrels in the Hertford bridge in Carolina, remained in service for fifty years.

The United States army in the Phillipines made floats of ten to fifteen bamboos, 25 feet long, tied together, and lying in the water 10 feet apart. They were buoyant enough to sustain wagons and light artillery. A very crude and unscientific method of floating the deck was that used at Lynn, where the whole timber platform was laid upon the water, and as the timber became water soaked and settled, other timber was laid over it, till the thickness had finally increased to 17 feet. Rafts 30 feet square made of flattened logs and connected by platforms, as in the bridge at Port Hope, were an improvement on the last and yet very defective.

Open top boats are used at Cologne, and wood barges for most of the pontoon bridges in America, including all those for railway service in the Middle West, the latter ones being divided into four separate compartments by three longitudinal walls. Barges with large bottom area have the advantage of small depression under live load, that at McGregor, 408 feet long and 30 feet wide, sinking only 8 inches under a locomotive. The pontoon 400 feet long at Reed's

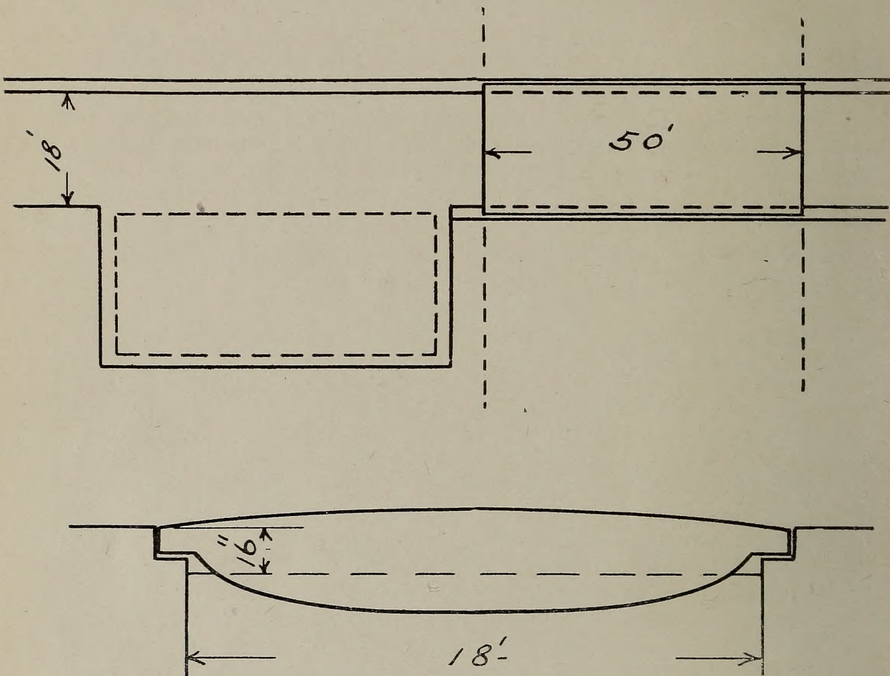

Fig. 1—Pontoon Bridge over the Royal Canal at the Broadstone Terminus of the Midland Great Western Railway, Dublin (1847)

Landing, is similar to that at McGregor, excepting that the depth is 7½ feet at the ends, while it is only 6½ feet through the central 320 feet, thus adding to its buoyancy at the ends under an approaching load.

Wooden boats are used at Toulon, but metal floats are the general rule in Europe and Eastern countries. Those for the Calcutta bridges are made of ¼-inch metal, and are 160 feet long, 10 feet wide and 8 to 11 feet deep, standing 3 to 4 feet above water, each one being divided into eleven compartments. Other examples are those at Riga and Coblenz. Scows and tugs beneath the outer end of revolving spans are used at Aalborg and Chicago, and Mr. Kinniple's submerged caisson bridge was partly supported by a buoy.

Centre Pontoon Under Double-Arm Swings

The benefit of this method of supporting a span is that it is independent of the shifting river bottom and the height of the deck can be adjusted by admitting or withdrawing water ballast. The buoy is held in position by a circle of piles, on top of which is a track for the balance wheels. The pontoon should be made in four to six parts bolted together, forming a cylinder and sections could then be replaced without removing the bridge superstructure. Hand pumps should be installed to remove water from leakage or condensation. The pontoon of the Weaver river bridge is 12½ feet deep and 30 feet in diameter, with the bottom slightly dished or spherical, and all metal 3-8-inch thick.

Buoys might be placed in regular bridge piers to reduce the pressure on the piles or foundation, but their lack of stability and durability has prevented such use. At Northwich, the buoys sustain 85 per cent. of the whole load, while on the earlier ones of 1873 at Spencer Docks, they carry 95 per cent. of the load.

Spacing of Pontoons

The distance between centres of buoys or pontoons is usually 30 to 50 feet, being 35 feet at Maxau, 40 at Attock, and 48 at Calcutta, but it may be regulated to suit the length and size of floor joist, the relative cost of floor and boat, and the required buoyancy. In the Attock bridge, 14 feet wide, boats 48 feet long and 12 feet wide, cost $286 each. Flotation may be regulated by water ballast, and the buoys can be anchored with chains or wire rope, the former being almost exclusively used until thirty years ago.

Details and Cost

Since water offers greater resistance than air to movement, floating bridges have a slower operation than bascules or swings, and should generally open with the current and close against it. One of the quickest moving pontoons is that at McGregor, on the Mississippi River, which opens with the current in one minute and closes against it in three minutes.

The kind of power and its method of application should be governed by circumstances. An old locomotive on shore was used for operating the bridge at Rouse's Point, while the double leaf bridge at Nebraska City is swung open by the force of the current. Temporary swing bridges in Chicago, supported at one end on a pontoon, were formerly operated by an electrically driven double drum, carrying two chains with their outer ends anchored on shore, but the more recent one in that city has electrical paddle wheels on the pontoon.

Floating bridges have frequently been assembled either up or down stream from their final location, in a place sheltered from the rapid current or from the enemy, and afterwards towed or swung around into position in either one piece or several sections. This plan was followed by Napoleon for a bridge over the Danube the day

before the battle of Wagran. The quiet water around an elbow of the river on the inner side is convenient for this purpose.

The time occupied in building pontoon bridges depends on the degree of permanence required, the preparation which has previously been made for such work, the skill and experience of the builders, and the availability of materials. Military bridges put up by men practiced in such manoeuvres and from parts which are carried by the army, have often been built in a few days, and one which was constructed during the American Civil War, over the Potomac at Harper's Ferry, was completed in eight hours. The Nebraska City bridge which is over 2,100 feet long, was built in twenty-eight days, while that at Maxau took twelve months and another at Calcutta, twenty months, delay being caused in the last case by waiting for materials from another country.

Timber pontoons such as those on the Mississippi, when built of creosoted timber, will last twelve to fifteen years, or at least half as long as steel, and if the pontoons are of metal, the duration of pontoon and swing bridges will be about the same. Their cost does not usually exceed one-third to one-sixth of the cost of metal bridges with swing spans.

Assyrian and Persian Bridges

The earliest pontoon bridges were probably those used by ancient armies, since they were mentioned by Homer as common in his time, about 800 B.C. The writings of Lucarus, Herodotus and Xenophon, state that pontoon bridges with casks as floats were used for military purposes. The earliest bridge of this kind of which definite records are extant is one made by Cyrus, King of the Persians, for transporting his army in the year 536 B.C., stuffed skins being used as floats. Babylon was taken 538 B.C. by the Persian army under Cyrus, diverting the course of the Euphrates and entering the city at night under the water gates of the river. The people in those days knew, therefore, both how to bridge the rivers and to dam them.

Darius Hystaspes, fourth King of the Persians, who began to reign 521 B.C., built a bridge of boats across the Danube River (510 B.C.) when engaged in his Scythian warfare. In 493 B.C., the same King, on a Scythian expedition, when about to invade Thrace, constructed a bridge of boats over the Bosphorus at a place where it was 3000 feet in width, over which he marched his army of 600,000 soldiers. His head bridge builder was Mandrocles of Samos.

In 480 B.C., Xerxes, King of the Persians, who succeeded his father Darius, built a double bridge of boats at Abydos, between Sestos and Madytus, over the Hellespont (or Dardanelles) which separates Europe from Asia. The strait varies from one to four miles in width, and the bridge is believed to have been at least 5,000 feet long. Herodotus says that the first bridge was destroyed by a violent storm, and in great anger, Xerxes ordered the engineers or builders to be executed and the water of the Hellespont to be scourged with rods and blasphemous words. Xerxes then built two other pontoon bridges, one of which on the side adjoining the Euxine Sea,

was supported on three hundred and sixty, and the other on three hundred and forty anchored boats of the largest size used by the ancient navies. The first were placed transversely, and the others parallel with the current, to diminish the strain on the cables. The boats were connected by six large cables of white flax, extending the whole length of the bridge and fastened to piles on either shore, the cables being drawn tight with wooden capstans. The platform, which was protected by a railing at each side, consisted of trunks of trees laid across the cables and covered with flooring and a layer of earth. When the work was completed, Xerxes ordered fetters to be thrown into the sea, signifying that he had conquered the turbulent waters. One authority states that at three places in its length openings were

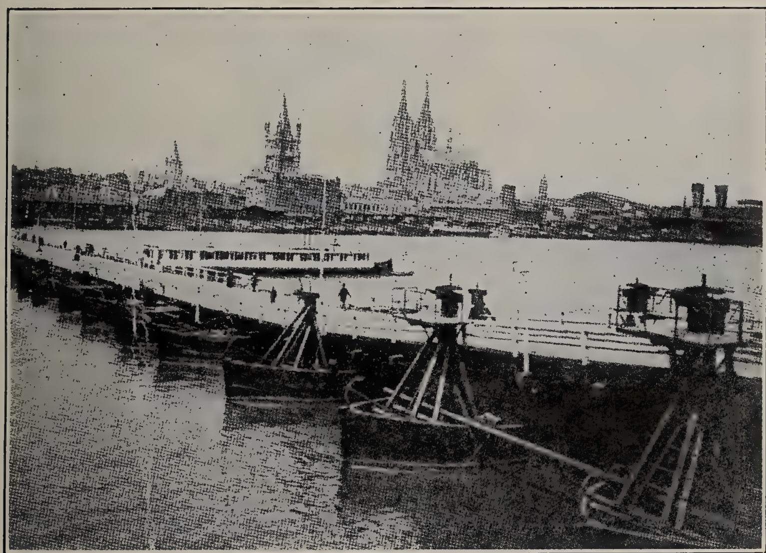

Fig. 2—Bridge of Boats over the Rhine at Cologne.

left for the passage of ships. The work was done by Egyptian and Phoenician artisans. Over these bridges Xerxes marched his army of 2,000,000 men across into Europe when on his way from Sardis to conquer Greece, and seven days and nights were occupied in making the passage.

Roman, Grecian and Chinese Bridges

At a later period, the young Emperor, Alexander the Great, built a pontoon bridge over the Ganges, about 330 B.C., for the purpose of transporting his soldiers, and in crossing the Oxus, 327 B.C., he used rafts made of hides stuffed with straw, as all the available boats had been burned. He was accustomed to carry with his army a kind of boat in sections, which could be joined together when re-

quired for use. Pyrrhus, King of Epirus (318-272 B.C.), also had a bridge of boats on the Adriatic Gulf. Caligula's bridge (see Tyrrell's History of Bridge Engineering) is thought by some historians to have been constructed chiefly on boats. It was three miles long, in the form of a crescent across the bays of the Puteoli and Baiae, or Tyrrhene Sea, and was supported over the water on a double row of boats or pontoons. The roadway was made of plank, covered with earth and gravel, and the deck was lined on either side with shops and houses, and was illuminated at night with torches. Caligula's boast was that he would turn sea into land and night into day, and when it was completed, the Emperor had great festivities lasting for several days, which teminated by his ordering a large number of the citizens to be thrown into the sea. The date of completion was in the latter part of his reign, about 40 A.D.

Movable boat bridges were common in China, and one in the province of Chausi at the junction of two rivers, was made with one hundred and thirty barges, chained together and so arranged that two or three boats were removable for the passage of vessels. In the fourth century, A.D., the Greeks under Emperor Julian, used boat bridges for crossing the Tigris and Euphrates rivers in their retreat from Persia.

Modern European Bridges

The Servians used a pontoon bridge for crossing the Danube in the fourteenth century, to assist in the defense of Nicopolis, and a bridge of boats over the Rhine between Cologne and Deutz, Germany, was constructed in 1674, and was replaced by a new one in 1822. It is 1400 feet long and carries highway and pedestrian travel, and has a wooden floor which is renewed occasionally as required. The Rouen bridge of boats, prior to 1810, was 900 feet long and paved with stone, and was very firm under heavy travel, the boats being anchored with chains. A bridge over the Neva at St. Petersburg prior to 1845, admitted ships at night through one opening.

A removable platform supported on a pontoon, was, in 1847 placed over the Royal canal at the Broadstone terminus of the Midland Great Western Railway at Dublin. Water in the canal was only 16 inches below the street and there was little vertical space for framing. The bridge is 50 feet wide, only 18 feet long, and can be removed by withdrawing water from the chamber by means of a syphon which is exhausted by a jet of water issuing into the exhaust pipe at an acute angle. The platform then rises from its bearings and is drawn into a recess in the approach at one side. The pontoon is made of half-inch iron plate and its total weight is 18 tons. It was designed by Robert Mallet and at the time, was a new departure in bridge construction. The cost was $6,375. Two parallel swivel bridges, each with a road 25 feet wide, were at first intended for the place but were not used.

The bridge of boats over the Danube at Budapest, which existed previous to 1837, was removed in the winter seasons because of danger from ice, and travel was taken over the river either in ferries or on the ice, which, in 1838, was 6 to 8 feet thick. For several months of

each year, travel had been accompanied with much uncertainty and risk, and as these conditions were not satisfactory in 1847, the new suspension bridge was erected. The pontoon bridge over the Rhine at Maxau near Carlsruhe, Germany, had a portion 768 feet long, supported on thirty-four pontoons, though the total length with approaches is 1,200 feet. It is 40 feet wide, with a single line of rail track in the middle and a highway on each side, but only light train loads and an 18-ton locomotive are permitted on the bridge. The wood pontoons are each 12 feet wide, 4½ feet deep and 65 feet long. It was opened in 1865 after twelve months in construction. One set of pontoons near each side of the river is, in summer time, moved three or four times per day to allow boats to pass. It replaced an ancient bridge a few hundred yards further up stream, and was designed by Messrs. Becker & Basler, Engineers. A bridge over the same river at Ehrenbreitstein also has a movable section.

The pontoon highway bridge over the Mangegarry Canal at Toulon is in two parts, hinged together. The roadway is 16½ feet wide supported on four wooden boats, which gives a passage of 30 feet when partly open and of 85 feet when fully open. Another bridge, 500 feet long, over the Havel at Spandau near Berlin, differs from previous practice by using wire ropes instead of chains for anchorage. It is supported on eighteen pontoons and the footway is elevated high enough that boats can pass under at two places, while a movable section at the centre on two pontoons, permitted the passage of masted ships. It was completed in 1883 and cost $5,250.

Floating bridges with hinged aprons at the ends are convenient for crossing small channels with varying water level, for the apron permits the central part to rise and fall. One of this kind for foot travel, crossed a small channel at Coblenz in 1888, the deck being supported on two metal pontoons, 1½ meters in diameter and 7 meters long, placed 10 meters apart. Above the floats were small towers, from the tops of which were ropes leading out to support the aprons at their outer ends. Another highway bridge over the Dunastrom at Riga is supported on buoys 3.2 meters in diameter and 26 meters long, spaced 19½ meters apart, with a deck 14 meters wide.

The Prame bridge over the North East Sea Canal (Kaiser Wilhelm Canal) at Holtenau is in two parts with a 15 meter road and two narrow walks, the total width being 20 feet. Each half is carried on boats and revolves about a pivot on shore. When closed, the two leaves meet in the centre of the canal forming an obtuse angle with each other. The main pontoons are made with ¼-inch plate and the whole bridge cost $30,000. It was originally worked by hand but was afterwards equipped with petroleum motors. The design has proved satisfactory in water with only small variation in level, but would be useless in tidal basins. Other interesting ones cross the Diena at Riga and the Weaver River at Northwic.., England, the latter being supported on a floating centre pier, while still others at Presburg, Coblenz, Mayence, Seville and Portsmouth might be described.

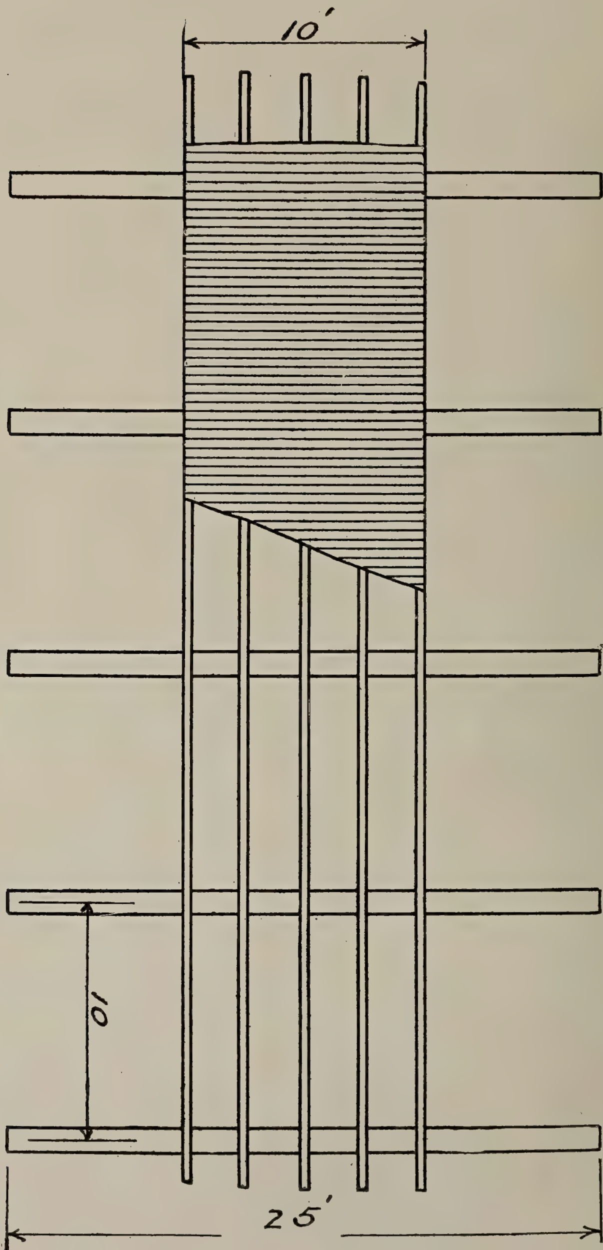

Fig. 3—Floating Bridge used by the United States Army in the Phillipines (1899).

Asiatic and Eastern Pontoon Bridges

Many of the finest and most interesting pontoon bridges are to be found in Asiatic countries, some of them the designs of English engineers. An early one of the last century is the Victoria bridge at Colombo, Ceylon, over the Kelani River at Grandpass, completed in 1825, and in use for more than forty years. The river is 450 feet across and rises 9 to 12 feet during flood seasons.

Bridges over the Golden Horn, that busy watercourse leading out from the Bosphorus to the north, and separating Constantinople from the suburbs of Galata, Topana and Pera, have long been maintained, one being erected in 1837. The deck of this bridge was 36 feet wide and most of it was near the water, but in two places were elevated platforms reached by grades, leaving openings at all times for small river craft. It was wholly of timber and was supported on floats, being divided into sections which could be removed for the passage of ships. Gables and anchors held it laterally in position. This old wooden pontoon bridge was replaced in 1872-75 by a new one at Karakeni, a contract having been made between the Turkish government and Mr. George Wells, a civil engineer of London. The original contract price for a bridge 1350 feet long was $475,000, to cross between Azap-capon and Oun-capon, but after the contract had been made, the government officials changed the location to a place which was 100 feet longer than the first, and they agreed to pay an additional sum of $30,000. But on receiving the iron from Newcastle, England, it was found to be 9 feet longer at each end than was provided by the abutments, and the grade level was therefore raised by discharging a portion of the ballast from the pontoons. The contractor demanded and secured damages for several months' delay, in the amount of $500 per day.

Another bridge over the same channel was completed in 1907, But the latest one from Constantinople (Stamboul) to Galata, which was begun in September 1910, was completed in the autumn of 1912, and replaced the one built in 1872-75. The other bridge, half a mile further up the channel, on account of its position, has only light traffic compared to that over the last one, which required an 82-foot roadway. The moving span at the centre has two passage ways 39 feet wide and 17½ feet high under it, through which small water craft can pass without removing the opening span, but when it is withdrawn, the clear channel is 205 feet wide. The new bridge is 1542 feet long, and contains 8,000 tons of steel, which was manufactured in shops at Mayence, Germany. Water in the channel is 130 feet deep, and as there is no tide, the greatest variation in level, caused by wind blowing continuously for a long time from one direction, is only one foot. The pontoons are arranged in two rows parallel to the bridge axis. In consideration of its population of a million, and the harbor facilities for 1200 ships in the Golden Horn, it would seem that Constantinople, the capital of the Turkish Empire, the harbor of which is used by not less than 37,000 ships annually, was poorly supplied with bridges.

Another large pontoon bridge, erected in 1873, crosses the

Hoghly River at Calcutta, India. It is 1530 feet long, and the deck is supported on twenty-eight rectangular iron floats coupled together in pairs, and held in position with 1¾ inch chain cables, fastened to anchors weighing three tons each. The anchors are placed on the up-stream and down-stream sides, and each pontoon is divided into eleven separate compartments, with the top three or four feet above the water. The pontoons are 10 feet wide, 8 to 11 feet deep, and 160 feet long to prevent their oscillating or tipping sideways. The deck is 63 feet wide and 27 feet above the surface of the river, which has a current of six miles per hour. An opening for the passage of boats can be made by removing a central section 168 feet long, resting on four pontoons, which operation is performed about twice per week. Before floating the section out, a portion of flooring 20 feet long at each side of the removable part is thrown back over the adjoining roadway, and when the moving part is withdrawn, there remains a clear opening of 200 feet. It is worked by hand power, and fifteen minutes is required to open the bridge, and twenty to close it again. It connects Calcutta with Hawrah, and at the time was the longest floating bridge in the world. Sir Bradford Leslie designed it in 1868, but it was not completed until five years later, after twenty months of actual construction. The quantities of material are as follows, the iron work being sent from England.

Iron in pontoons	1600 tons.
Iron in girders	875 tons.
Timber	1500 tons.

It cost $1,000,000, which was only one-third the estimated cost of a fixed bridge of the same width.

In recent years, the need for a more commodious bridge at Calcutta has become evident, and in the early part of 1912, competitive designs were received for a new one. Since the river bottom is soft mud and silt to a great depth and quite unsuitable for piers or foundations of any kind, transporters and floating bridges were the only types seriously considered. Two designs with floating piers, submitted by Head, Wrightson & Company, of Thornby, differed only in the piers, for in one case. buoys were to float on the surface of the water which had a maximum rise and fall of 20 feet, and in the other design, the buoys were to be anchored below water and remain stationary regardless of the water elevation. The clear distance of 1408 feet between abutment faces was to be crossed by a 500-foot shore span at each side, with a double leaf swing in the center, leaving a clear space of 200 feet between the floating piers. These plans showed a deck 98 feet wide with three lines of trusses, which is 50 per cent. greater than the former one. Each pier consists of eight buoys, 15½ feet in diameter and 228 feet long, spaced 18 feet apart on centers, the buoys being divided into five separate bulkheads.

Pontoon bridges have been extensively used in other parts of India, such as those at Dera Ismail Khan, Attock, and Khushalgarh. The bridge at Attock was 1200 feet long supported on boats 48 feet long and 12 feet wide, placed 40 feet apart on centres and

costing $286 each. Over the boats were trussed joists and a plank roadway 14 feet wide. The bridge over the Indus at Khushalgarh was recently replaced by a cantilever. Small bridges of this type are also common in India, five of them with lengths of 310 to 558 feet having been built from 1900 to 1902. Pontoons 6 feet in diameter and 30 feet long of 3/16-inch steel plate are placed 31 feet apart on centres and anchored with chains 100 feet apart. Narrow roadways about 10 feet wide, guarded at each side by a fence of light chain, are carried by two lines of 10-inch steel joists. Each of these bridges contains a hinged bascule supported on double pontoons, which can be opened by two men in fifteen minutes and closed in six minutes.

Floating military bridges used by the United States Army in 1899 in the Phillipines, had floats 10 feet apart and 25 feet long, made of fifteen bamboos tied together, over which was laid a deck of bamboo mat, 10 feet wide, no nails being used in any parts. One of these bridges 290 feet long, over the Iloilo River at Molo, was completed in four days by ten men at a total cost of only $125.

American Pontoon Bridges

One of the earliest floating bridges in the United States and probably the only one of its kind, was built in 1802 near Lynn, Mass., over a pond which was believed to have no solid bottom. It was built by Moses Brown, and was 511 feet long in three sections. The platform was of timber 5½ feet thick, but it had so often been refloored, that its thickness in 1904 was 17 feet. It was then so water-soaked that light loads passing over it caused it to sink below the surface, and it was replaced by a modern bridge, though the old one was allowed to remain. A somewhat similar one crossed Dexter Pond in Maine. One at Hertford, North Carolina, was supported on empty barrels and was used for fifty years. A bridge similar to that at Lynn, was made by George Steward of Port Hope, Ontario, who many years ago built a floating bridge like a corduroy road, three-quarters of a mile long, between Sturgeon and Scugog Lakes. Rafts 30 feet square, of flattened timber, were connected by six or seven longitudinal beams on which a platform was laid.

Pontoon bridges were largely used by the American armies during the civil war, of 1862-65. One over the Potomac at Harper's Ferry, Va., containing sixty boats, was built February 1862, in a period of only eight hours. The river was in freshet condition, 15 feet above summer level, and was filled with ice and drift, but when finished, safely carried the heavy army wagons, cavalry and artillery. The Rapidan, Rappahannock and other rivers were similarly crossed.

One of the most important commercial bridges of the kind was that which was built in 1851 over the outlet to Lake Champlain near Rouse's Point. The principal part of this structure was a pile trestle 1800 feet long, but it contained a pontoon draw 300 feet long, which was operated by an old locomotive engine on shore. It was built by Henry R. Campbell, and gave good service until removed in 1868. It was 30 feet wide, and 7 feet high, drawing 2 feet of water. The

experience with this bridge was valuable, for it served as a model or prototype for several others in the Middle West in later years, including those over the Mississippi at McGregor and Reed's Landing. The bridge between Prairie du Chien, Wisconsin, and North McGregor, Iowa, built in 1874, carried the Chicago, Milwaukee and St. Paul Railroad over the Mississippi River. It was the work of John Lawler, who first examined that at Rouse's Point before putting this one into execution, which he afterwards patented, prior to his death in 1891. Before building it, cars had been taken over the river on a ferry. The river is divided by an island into two parts, the west channel being 1500 feet wide and the east one, 2,000 feet. Excepting for the two removable parts, the remainder of the bridge was a pile trestle. As first built, the pontoons were 408 feet long, 28 feet wide and 5 feet deep, drawing 10 inches of water, which depth was increased to 18 inches when loaded with cars. As the range from low to high water is 22 feet, the track was blocked up between stiffening trusses on the deck, and it could be lowered during high water to suit the grade of the approaches. It was operated by a 20 h.p. steam engine, and could be opened with the current in one minute, and closed again against the current in three minutes. When open, the channel width of 408 feet was reduced by the width of the pontoon, the remaining distance being 380 feet. Log rafts in the river were usually 320 feet long or wide, and experience showed that the river men liked this bridge and found it easy to pass. Therefore, in later years, as renewals were needed, it was replaced by structures of the same kind, which were found to cost only one-sixth as much as the cheapest swing span on the river. Renewals were made in 1882 and 1888, and a new pontoon was placed in the east channel in 1898, and another five years later in the west channel, the new floats being made 30 feet wide on the bottom and 41 feet at top. They were divided by three longitudinal walls into four compartments, and each one contained 600,000 feet, B.M. of timber. These bridges are suitable in gentle currents only, and where ice can be easily broken. When built of good material, they should last twelve to fifteen years. This one is opened on an average about five times per day, and is in service about 250 days of each year, which time represents the whole open season.

The Chicago, Milwaukee, and St. Paul Railway maintains another pontoon bridge at Reed's Landing near Wabasha over the Mississippi River, 1½ miles below Lake Pepin. The main part of the bridge is a pile trestle 3,500 feet long, but it contains a 400-foot pontoon which, when open, leaves a clear channel of 350 feet. It was first finished in 1882 and was rebuilt in 1891, much of the trestle being filled in with rock. At low water, the river is 2,400 feet wide, and the variation in level is 15 feet, with a swift current. The barge is 6½ feet deep through 320 feet of its central part, and 7½ feet at each end, and altogether, it has given such good service, that it was rebuilt again in 1907 with creosoted timber.

The Missouri River bridge at Nebraska City, finished in 1888, has a length of 1074 feet over the navigable water, with 1050 feet of

causeway on cribs over a back channel, when completed was the largest of its kind in the world. The moving part, 528 feet long, is a triangle in two leaves with apex down stream, and to open it, the connection at the centre is loosened when the current swings the halves apart, the services of only one man being needed. The width is $24\frac{1}{2}$ feet for highway and pedestrian travel. It was built under the direction of Colonel S. N. Stewart of Philadelphia, and the whole structure, including approach, was completed in twenty-eight days at a cost of $18,000.

John Lawler also built a highway pontoon over the Illinois river at Lacon, Illinois, in 1889, though it was designed by George F. Wightman, of Lacon, in 1879, and afterwards built under his direction. The pontoon is 200 feet long, 24 feet wide and 6 feet deep, but the remainder of the bridge is a pile trestle. It cost $17,000, and as

Fig. 4—Old Bridge on Chicago River, from Goose Island to East Bank, one end on Pontoon

the toll received is $4,000 per year, it was renewed in 1905 by another one, of the same kind, but 50 feet longer than the original. It is operated by two men. The river is 38 feet deep at low water and has a maximum rise of 18 feet, 40 feet of the deck on each approach being movable to connect with the pontoon on the water with varying elevation.

The competition of 1892 for a moving bridge over a 250-foot channel at Duluth, brought forth three designs for a single leaf swing bridge supported at the outer end on a pontoon and mounted on a turntable on the other shore. These were made by Messrs. Bates, La Rue and Stebbings, and in all cases a recess was left in the dock, adjoining the turn-table, to receive the pontoon when the bridge was open. In Mr. Bates' design, the bridge was lifted from its bearing by pumping water from the pontoon, and then turning it by means of a

screw in the water. The estimated cost was $80,000. Mr. La Rue's design was similar, excepting that the outer end of the bridge rested on a steam tug 20 feet wide and 70 feet long with 15-foot draft, the total cost being estimated at $108,000. Mr. Stebbings' design was to cost about $135,000. All of these were quite similar to a bridge erected at Aalborg, Denmark in 1867. (See Heinzerling's Bridges). The following year (1893) when the bridging of the Detroit River was being discussed and opposed by the river interests, a patent was granted to Mr. E. Fontaine, of Detroit, for a so-called "winter bridge," consisting of girders supported on hinged bents, the intention being to float the spans away on barges or pontoons, and to revolve the bents down on a submerged platform well below the reach of ships. But it is now well known that opposition to the bridge was so severe that a tunnel was driven under the river instead.

The pontoon highway bridge over a harbor on Curazoa Island, in the Dutch West Indies, 46 miles north of Venezuela, is 700 feet long with pontoons 30 feet long and 20 feet wide, spaced 30 feet on centres. It was designed by L. B. Smith, and the removable section 400 feet long is worked by cables from an engine on shore.

A bridge, the length of which is 3638 feet, containing unusual features, was built over Chemong Lake near Peterborough, Ontario, in 1900. The fixed approach is 913 feet long, and the pontoon portion 2620 feet, which contains a draw of 105 feet. At five places the road is 24 feet wide to permit vehicles to pass, but the remainder of the deck is only 18 feet wide. Its cost was $26,000.

A bridge over Salmon Bay at Seattle, Wash, was proposed in 1902, the total length of which, including the approach would be 1,200 feet. It was intended to be 60 feet wide for a highway and two railway tracks with the deck 20 feet above water. The floating part would consist of eight scows 20 by 50 by 5 feet, resting on the bottom at low water and connected by several short spans, and the draw would consist of two counterweighted lifting spans 50 feet long, on scows 60 by 100 by 6 feet, giving a clear opening of 100 feet.

Temporary swing bridges supported at one end on a pontoon, have frequently been used at Chicago during the construction of permanent bascules, a design for one at State Street having been made in 1902, though not then used. It was quite similar to a bridge built at Aalborg, Denmark, in 1867, and to those proposed for Duluth, ten years before. The design for State Street was intended for pedestrian travel only, with a clear width of 10 feet, between trusses 117 feet long and 12 feet deep. One end was to be pivoted on a pile pier, while the other end was bolstered up on a timber pontoon, leaving an underclearance of 16 feet, 60 feet wide when closed, and 100 feet wide when open. The pontoon was 20 feet wide and 7 feet deep, 38 feet long on top decreasing to 20 feet at the bottom, carrying three lines of timber trusses which supported the outer end of the bridge. But the first one of the kind actually used in Chicago, was at Northwestern Avenue, where the trusses of the moving part were 100 feet long with 8-foot panels, carrying a roadway and two lines of car track over a clear channel of 72 feet. Floor beams were

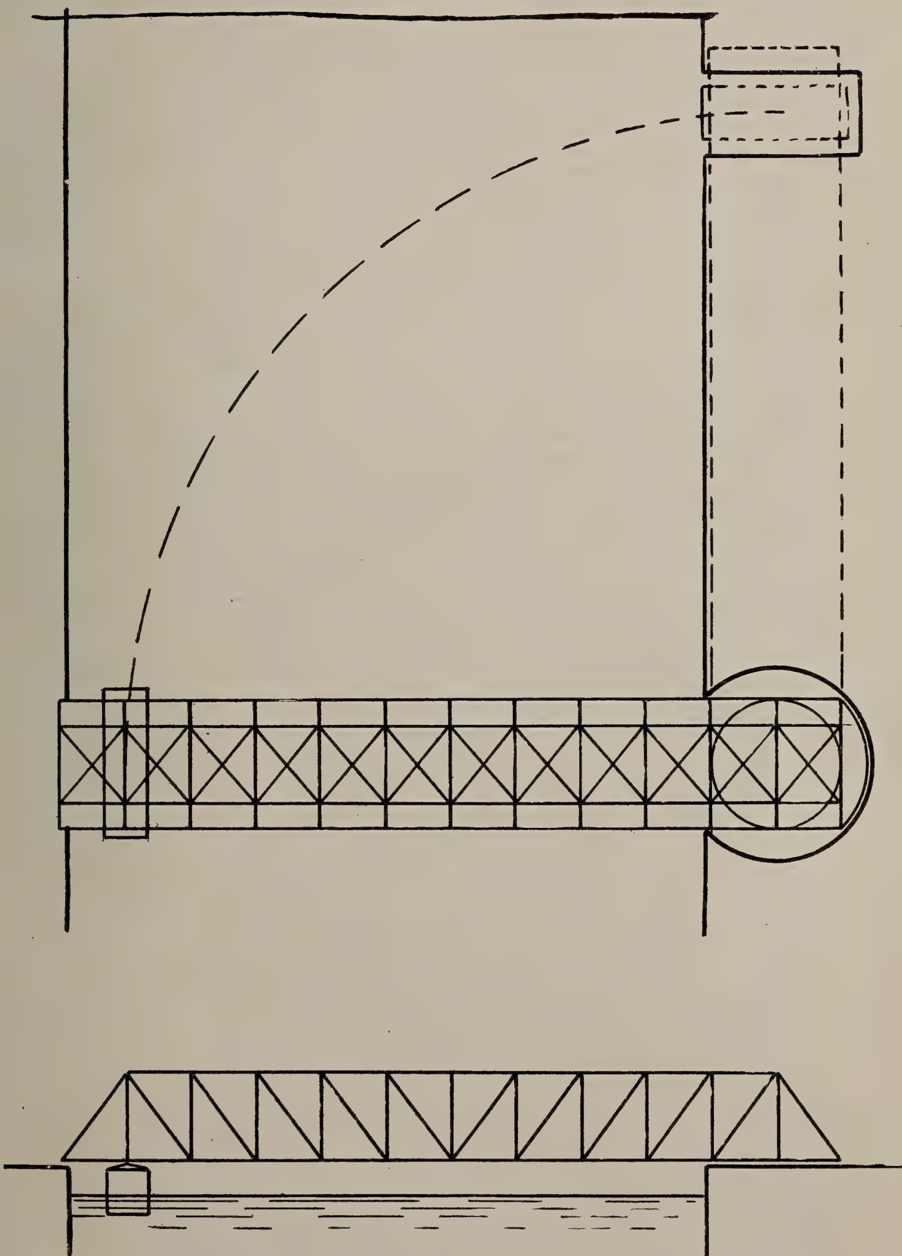

Fig. 5—Mr. Onward Bates' Design for a Bridge to cross the Channel at Duluth (1892)

two feet apart, and the total dead weight was 100 tons, or 2,000 pounds per lineal foot, 85 per cent. of which was supported by the scow. The whole bridge 212 feet long with the approach trestle, cost $10,000, but the moving span with pontoon and machinery cost only $5,600. The scow was propelled by electrically driven double drums, carrying two chains with their outer ends anchored on shore. Other similar bridges were used in Chicago at Archer and North Avenues. The North Avenue bridge, where the river is 195 feet wide, was similar to that just described, excepting that the scow, 15 feet wide and 40 feet long, was equipped with electric paddle wheels instead of drums with chains.

A railroad bridge over the Missouri River at Chamberlain, North Dakota, completed in 1905, has a pontoon 360 feet long similar to that at Prairie du Chien, leaving a clear opening of 300 feet.

M. H. Baker, '06, until recently the city engineer of St. Thomas, Ont., is now city engineer of Prince Albert, Sask.

E. H. Phillips, '00, and A. P. Linton, '06, presented very interesting papers at the annual meeting of the Saskatchewan Land Surveyors in Regina.

At the annual meeting of the Association of Ontario Land Surveyors, J. S. Dobie, '95, was elected president for the coming year.

A. A. Kinghorn, '07, for seven years connected with the works department of Toronto, and for the past several years superintendent of roadway construction, is now manager of the Asphaltic Concrete Co., Limited.

J. Hutcheon, '90, civil and municipal engineer, Guelph, has accepted a position in the Department of Lands, Forests and Mines at Toronto.

H. Gall, '10, until recently with the Canada Foundry Co., is now assistant engineer to Frank Barber & Co., Toronto.

M. Pequegnat, '08, for several years demonstrator in drawing, leaves the staff at the close of the term to assume the duties of engineer of Berlin, Ont.

A. Schlarbaum, '09, is hydro-electric engineer for the Riordan Pulp and Paper Co., at Merritton and Hawkesbury, Ont.

V. C. Thomas, '08, has accepted a position with the Ontario Power Co. at Niagara Falls, Ont.

F. C. Rust, '11, is in the engineering department of the Vancouver Island Power Co., Limited, at Victoria.

G. P. Stirrett, '08, is resident engineer for the Canadian Northern Pacific Ry. at Spence's Bridge, B.C.

J. E. Grady, '09, is instrument man for the Transcontinental Ry. at Cochrane, Ont.

C. K. Nixon, '11, is engineer of tests, with the Edison Illuminating Co., of Detroit, Mich., in charge of the testing of isolated steam, gas, etc., plants for the benefit of consumers about to install electric power.

THE MAKING OF GOOD ROADS

By W. B. Dunbar, B.A.Sc.

The construction of roads, or artificial ways, is one of the first steps taken with the spread of civilization in the opening up of a country for the accommodation of travellers and the carriage of commodities. Road builders may be looked upon as pioneers in the material advancement of a nation, the condition in which the roads are maintained being a fair indication of the progress or prosperity of an age or people. Canals and railways have, no doubt, in modern times superseded, to some extent, the common highways; yet, these retain their importance, if only as essential auxiliaries.

The natural resources and manufactures of a nation can only be developed by communication between towns and rural districts, or, in other words, the road is so necessary an instrument to social well-being that in every new colony it is one of the first things thought of. The new country as well as the old can only be effectually opened up by roads, and until these are made it is virtually closed.

The evolution of the modern road can only be adequately understood by reference to the practice from the time when the great military roads of the Romans were built to the present time.

The Romans were undoubtedly the greatest road builders of ancient times. Owing to the situation of their vast possessions and their desire for conquest, it was very important that they should have a rapid and satisfactory means of travel. Except where some natural barrier made it impossible, the Roman roads were almost invariably in a straight line, probably because the chief means of transport then in use were beasts of burden and not wheeled vehicles, which made the preservation of the level of less consequence. Investigation proves that the Romans were masters of the art of road building. The substantial character of their roads is perhaps best demonstrated by the fact that they have, in some instances, borne the traffic of two thousand years without material injury. A good example of this is the Appian Way, one of the earliest and most famous of roads.

The reputation of many of the pioneers in civil engineering was, to a large extent, based upon their success as road builders. It is well known that the art of road-building in Europe has practically disappeared with the Roman Empire, and from one hundred and fifty to two hundred years ago the arteries of commerce were so defective in these lands that freight had to be transported, to a large extent, by pack trains, the apologies for roads being almost impracticable for wheeled traffic.

The pioneer of modern methods of road-building seems to have been M. Tresaguet, who was appointed inspector-general of the French department of roads in 1775. He was followed by Telford and Macadam, in England, the former's splendid road from London to Holyhead being one of the greatest engineering feats of his day. Not only was the road better than the track it replaced, but it effected

a large saving in distance over the old, and still more important, the total height up which loads had to be lifted was reduced.[1]

It is well known that the great movement for better roads set on foot by Telford and Macadam received a set-back with the introduction of railways. As these become more and more evident, traffic fell away from the country roads, except such as acted as feeders to the railways. The principles of Telford and Macadam were forgotten, or at least set aside, and the condition of the roads fell into a deplorable state.

However, with the popularization of wheeled vehicles for pleasure purposes in the early eighties, complaints as to the dangerous and defective condition of many of the roads were rife. The introduction of motor cars has, without doubt, revived the dust problem, of which little has been heard since the passing of the stage coach. But the dust problem is not the only one to be faced. The increased use of motor vehicles for pleasure and commercial purposes, and the use of steel studs, chains, and other non-skiding devices have called the attention of the country at large to the unsatisfactory construction of the roads.

In the early days of Canada, when the only means of traffic by land was on foot, the roads, or trails as they were called, were only distinguishable from the surrounding bush by blazes on adjacent trees. But as the country became settled, the desire for a better means of communication was manifested. The settlers, banded together, cut paths through the forest, and cleared them so that wheeled vehicles could travel. These served for a number of years, but were replaced by the turnpiked earth roads. As years went on, and the condition of the country improved in many ways, the roads experienced a corresponding improvement, and the construction of highways was given over to associations which financed the improvement by a system of toll-gates. There a toll was collected from all except pedestrians, who passed along the road. Soon, however, municipalities took over their own roads, and the days of corduroy roads, log culverts and fords, passed into history.

In regard to the advantages of good roads, nothing has as yet been said, but it is a question which cannot be overlooked. Good roads bring progress and prosperity to the community. Not only do they increase the value of the adjoining properties, but they aid greatly in the social and educational welfare of the community. In regard to cities, it is acknowledged that good roads go a long way in the solution of the question of the high cost of living. They allow the farmer, by reducing the cost of transportation, to market his goods at a lower price, and still make a substantial profit. Well paved city streets and country roads make habitations along them desirable and encourage pleasure driving. Noiseless and comparatively dustless pavements are being recognized as essential elements in maintaining the health of a community, and not the least of the good results is the bringing of country and city into closer relation with one another.

1 Roads and Road Making, Eng., July 15, 1910.

The direct benefits to country districts are many:

1. Decrease in cost of haulage.
2. Better facilities for marketing. For those living near cities advantage of market gardening.
3. Marketing of produce at most favorable time.
4. A wider choice of market.
5. Equalizing of railway traffic and mercantile business between different seasons of the year.
6. Promotion of social and intellectual intercourse between members of rural communities, also between rural and urban populations
7. Consolidation of rural schools and the increase in their economy and efficiency.
8. Facilitation of rural mail delivery.
9. Increase in value of rural properties.

Cities derive their benefit in the following ways:—

1. Decrease in cost of transportation.
2. Increased fire protection.
3. Improvement of appearance of streets.
4. Improvement of standard of sanitation and health.
5. Facilitation of social intercourse and pleasure driving.
6. Enhanced value of property.

Many advantages are common to both city and country. Thus, seeing what is offered by a system of good roads, is it any wonder that the country, as a whole is being aroused into action for the betterment of their condition?

Width of Country Roads

In laying out country roads, there are many conditions which have to be considered. The traffic on a road is one of the main points defining the width. Will the traffic always remain light, or is there a chance in the future, of the road becoming part of a village or town, or of a main road leading to a town or city? The greater the width of a travelled roadway, the greater the cost of construction, and in this country of frost and sunshine, the greater the difficulty of maintaining a satisfactory surface. An earth road of greater width than twenty-four feet cannot be efficiently drained. When such a road of greater width is crowned sufficiently to shed the surface water to the ditches, a vehicle driven along the side is necessarily tipped to an inconvenient or uncomfortable angle, and hence the tendency to keep traffic in the middle of the road. The result is that frost and rain destroy the road surface to such an extent that, when the frost disappears in the spring, it leaves the crown so uneven that it holds water over its entire surface and makes the road practically impassible. When this surface, so rutty and broken, finally dries out, the roughed-up material is ground to dust by traffic, and is either blown away, or remains to form mud when frost and wet return.

The average carriage which traverses a country road occupies from five to six feet of road surface and it is hence, able to pass

another comfortably on a roadway from fourteen to sixteen feet in width. The widest vehicle in use is, perhaps, the wagon loaded with hay. This will cover, in extreme cases, a width of not more than twelve feet, and hence could pass another comfortably on a road twenty-four feet wide.

The question of roads on hills must also be considered. An excessive width of road (especially on steep hills) is in danger, in times of heavy rainfall, of being washed out by water using the wheel tracks instead of the ditches as a means of run-off. With a narrow road the danger is not so great, since sufficient crown can be obtained without making the side slopes too steep for this to occur.

The regulations respecting highways, published by the Provincial Government of Ontario, call for a width of roadway on cuts and fills of not less than eighteen feet. Main roads should be graded to a width of twenty-four feet, and roads of least travel should not be less than eighteen feet.

The engineer, in laying out the roadway for surfacing, must use his own judgment as to the width which would be most suitable for

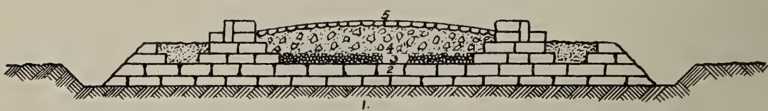

Fig. 1. Cross-section of The Appian Way—1, Solid subsoil; 2, Flat stone laid in mortar; 3, Well beaten Rubble; 4, Gravel or broken stone and lime; 5, Stone blocks fitted into place

the particular traffic for which the thoroughfare is intended, but an average width seems to be twenty to twenty-four feet on the level, and sixteen to eighteen feet on heavy grades.

Width of Town and City Streets

In considering town and city streets, the main elements which determine the width are traffic, cost, and, in built-up sections, the proximity of buildings. Before commencing the discussion, however, we must classify the streets according to the traffic they must carry, or the district they are intended to serve. The three main districts are wholesale, retail and residential, but in laying out streets for these considerable foresight has to be used, as it is often difficult to tell to which class a new street may belong.

As a rule, a wholesale street is not a thoroughfare, and consequently, a width that will satisfy local conditions will be sufficient. But one tier of trucks can be loaded in front of any building at one time. The largest trucks, when in position for loading, occupy from ten to twelve feet. If the opposite side of the pavement be so occupied, twenty to twenty-four feet in all will be blocked to transient travel on the street. In general, the width of the roadway should be sufficient to allow trucks to load on both sides without impeding the lines of traffic each way. If a width of forty feet be assumed, a width of sixteen feet will be open to traffic. It is probable

that both sides of the street will be occupied most of the time by the largest trucks, so that traffic could move fairly well in both directions under these conditions.

Retail streets are governed by different conditions. The street is used by a large number of both vehicles and pedestrians, hence, a larger sidewalk has to be provided, and this will necessarily decrease the width allotted to vehicular traffic. In general, since the majority of vehicles will not occupy more than eight feet of roadway, a width of thirty-two feet will be ample allowance for vehicles standing at the curbs, and a line of traffic each way in the centre.

Streets with car tracks should have a width sufficient to allow a team to pass between the car and another team standing at the curb. To accomplish this, a width of forty-four feet would be required. However, existing conditions must be taken into consideration, and the sidewalk not made too narrow.

For residential streets, or any streets not in the business section, allowance for three lines of traffic will be sufficient. To accomplish this, there will be required a width of twenty-four feet. This leaves room for boulevards, which add much to the appearance of a residential street. But on such streets used as thoroughfares, and on those with car tracks, a width of thirty feet will better satisfy the conditions.

Drainage—Surface and Subsoil

Good drainage is the first principle of road-building of any kind. The life of a pavement depends on the foundation which is really the underlying earth. The ability of earth to sustain a load depends almost entirely on the amount of water it contains. Most forms of earth make good foundations when kept dry, but when allowed to become soaked with water, are soft and soggy, and utterly unfit to withstand pressure.

Efficient drainage should consist of two kinds, surface and subsoil. The former provides for the speedy removal of water coming in contact with the surface of the road, and the latter for the removal of water from the subsoil, without which the life of the road is materially shortened.

Surface drainage is provided for by making the surface convex, thus running the water to the sides, and the subsoil drainage by a system of drains. A road built on a wet foundation will soon be destroyed by action of water and frost, and while it lasts, will be troublesome and expensive to maintain.

Different kinds of earth hold water to a different degree, and hence, require different forms of drainage. A sandy or gravel foundation will require little or no drainage, being sufficient in itself, but one of clay retains the water, and must be drained.

The centre of all roadways should be higher than the sides; the difference in elevation depending to a large extent, on the road material, the longitudinal grade and the traffic it must sustain. Hence, rules for the proper crowns to give roadways can only be used as limited guides.

Many formulæ have been compiled with the view of reducing to a certainty the proper crown to give roadways, but if all elements are to be considered in the determining of street crowns, it will become too complicated a production to express in any formula that would be useful for designing purposes. What is wanted is a shape that will drain rapidly and easily, and at the same time, be as nearly flat as possible in order that it may not interfere in the freighting of heavy loads.

The forms of crowns are many and varied, among which the most prominent are—circular arcs, two straight lines joined by the arc of a circle, compound curves, elliptic and parabolic. The most suitable forms, however, seem to be the circular arc or parabola. These give the maximum fall at the gutter, which is a desirable feature.

A universal practice is to express the height of the centre above the gutter as a proportion of the width of the roadway. The following gives a very satisfactory rule for constructing crowns on country roads.

Kind of Surface	Rise in centre in prop. of width.
Earth	1 : 40
Gravel	1 : 50
Macadam	1 : 60

It is considered a good rule to establish ⅞ of the total rise at ¼ the width from the centre to the side, and ⅝ of the total rise at ½ the width of the roadway.

City streets are, as a rule, constructed of paving material other than the above, and do not require as much rise at the centre. The most suitable proportions for the different paving materials are given in the following:

[1]For pavements having a smooth surface, such as asphalt, creosoted blocks, grouted stone blocks, and brick, and having grade of two per cent., or less, with no car-tracks, make the crown one inch to each six feet width between the curbs.

For pavements having more secure foothold, such as stone blocks and brick with bitumen filled joints, Macadam and bitulithic, on streets having a two per cent., or less grade, make the crown one inch to each four feet of width.

If the street has car-tracks, deduct the total width outside to outside of rails from the width between curbs, and divide the difference (double width between track and curb) by six and four, respectively.

For grades between two per cent. and four per cent., use one-half the crown provided by the above computation.

For grades above four per cent. provide a crown equal to one-third that of above computation.

Provide one-third of the lateral fall between the crown and the quarter, and two-thirds of it between the quarter and the curb. By "quarter" is meant the point midway between the centre of the

1 Roadway Crowns—Warren—Can. Eng.—April 29, 1910. Page 420.

roadway and the curb, or, in the case of car-tracked streets, the point midway between the outside rails and the curb.

With regard to fixed formulae for road crowns, many have been devised, but all, in some manner or other, fall short of the desired attainment.

Under Drainage

Wet subsoils on country roads should be drained by a system of transverse drains, constructed of three-inch terra cotta or burnt clay tile, laid in V-shape with the point directed slightly up-grade. This point should be at least eighteen inches below the subgrade of the road, and the drains should have sufficient fall to run the water away readily. The distance between such drains may vary from fifteen feet to forty feet, according to the character of the soil, and the amount of water it contains.

The practice of putting these transverse drains at right angles to the direction of the road is not a satisfactory one, on account

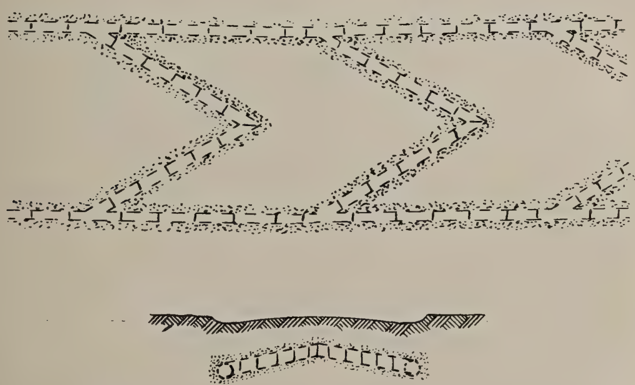

Fig. 2. Plan and section of V-shaped Drainage System

of the comparatively small area served by each of the drains. These transverse drains may empty into longitudinal drains under the curbs, and thence into the ditches, or directly into the ditches, in which case the outlet should be protected by a small wall of stone, brick, or other material from action of frost, and precautions should be observed to prevent choking up of the outlet.

In city streets where a practically water-proof pavement is laid, no transverse drains are necessary. Since no water enters the subgrade through the surface, the only source of danger is from percolation underneath the curb, or leaking water mains or sewers. This, however, is taken care of by placing a tile drain at a distance below the curb in order to lower the water line of the surrounding earth to a proper level below the pavement.

Curbs and Gutters

When the water has been drained from the surface of the road, it is caught in the gutter at the sides, and thence run through gullies into the sewers.

Closely associated with the gutter is the curb which forms a side for it to carry away the water, as well as defining the lines of traffic and improving the appearance of the roadway. As a factor in defining the street, the curb has to resist a great many disturbing forces, which may be classified as fcllows:

1. Pressure of earth behind, often augmented by piles of merchandise and building materials, tending to overturn it, break it transversely, or move it bodily from its base.

2. The pressure due to expansion of freezing earth behind and beneath it, especially where the sidewalk is partly sodded, and the ground is accordingly moist, tending to thrust the curb forward.

3. Concussions and abrasions caused by traffic, the defacement and injury caused by fires built in the gutters, and the breaking, displacing and destruction resulting from posts and trees set too near the curb.

The materials employed in the construction of curbs are: natural stone, such as granite, sandstone, etc.; artificial stone; concrete; iron, and vitrified clay blocks. Great care has to be exercised in the placing of the block forms, due to the tendency to displacement. However, if set in concrete, they form a very satisfactory curb. On account of the ease of construction, and the fact that it can be built in place, the concrete curb is coming into general favor, and in connection with the higher forms of pavement, the continuous curb and gutter. The attention of the reader is called to the city of Toronto specifications for concrete curb, as being essential to a more thorough knowledge of the subject of curbing.

From the gutter, the water is led through gullies into the sewers. They should be placed at intervals of two to three hundred feet along the gutter, the grade of the latter being such that the water will run away readily. A plan employed with much satisfaction in many cities is to locate the sewer under the centre of the street to which connection can readily be made with the gullies.

In country roads the water may be led directly into the ditches from the gutters, or drains may be placed below the gutter and filled with cobble stone and gravel, through which the water can percolate.

Gullies may be of brick, stone, iron or concrete, covered at the level of the pavement with cast or wrought iron gratings, or they may be let into the curb. The essential points of a street gully are:—

1. Area of open gratings and outlet drain should be sufficient to cope with heavy or sudden rainfall.

2. The grating must be so constructed as to permit of least possible obstruction or choking on its surface by road detritus, paper, straw or leaves.

3. Gully must be of adequate capacity to retain road detritus below the outlet pipe, and so prevent its entrance to the sewer.

4. It should be so constructed as to be easily cleaned out and readily cleared, should a stoppage occur.

5. Grating should be such that it will form the least possible obstruction to traffic.

6. It should be constructed of material not likely to be injured by tools used for cleaning. It should be strong and thoroughly water-tight, and extend far enough below the pavement to prevent damage by frost.[1]

Ditches and Culverts

Side ditches are provided on each side of the traveled roadway in the country, to carry away water from subsoil drains, and also that which falls as rain and snow on the surface of the road. They also intercept and carry away water from side hills and cuttings which would, otherwise, run upon the road.

The size of these ditches is determined by the drainage area, the amount of rainfall and the condition of the surrounding earth. The side slopes of ditches should be in the proportion of one and one-half feet horizontally to one foot vertically. The bottom, wherever practicable, should be at least twelve to eighteen inches wide, and the tops of the ditches should seldom be less than four feet wide. The depth should be such that the water will have the least possible chance of attaining the height of the road-bed.

The grade of the ditches should be great enough to drain the water rapidly away instead of allowing it to soak into the road-bed. In many cases, the natural grade of the adjacent ground will be sufficient, but in nearly level territory, an artificial grade will have to be provided. For this case a fall of two feet in each 500 to 800 feet will usually suffice. The ditch should have a free outlet to some stream or artificial waterway to keep the water moving, and the bottom should be free from pockets or depressions which would tend to hold the water.

On heavy grades, the bottom and sides of the ditches should be protected from the scouring action of the current created. A velocity of twenty-four feet per minute will loosen and transport particles of clay and sand. To overcome this, the ditches may be paved with cobble-stone, or small stone wiers may be constructed across the stream, thus slackening the current, and causing it to deposit suspended material.

Culverts

Wherever it is necessary that water should cross the road, whether it be that from side ditches or from small streams, a culvert should be built. The first essential in culvert construction is the size, which depends on the amount of water to be carried away. If made too small, and not specially protected at times of heavy rainfall there is a danger of the water damming up and causing a

1 Road Making and Maintenance---Aitken---Page 385.

washout; while, on the other hand, if too large, the construction is more costly than necessary.

The factors which enter into the problem of run-off are the area of the drainage basin, maximum rainfall per hour, the slope of the surface, the character of the soil, whether porous or compact, and whether or not it is wooded. Many tables have been prepared giving the size of culvert for any drainage area for a given rainfall. The following gives the area required in the locality where the average rainfall is thirty-five inches, which is approximately that of Ontario.

Column D Areas of drainage in square miles.
Column W Areas of waterway in square feet.

D	W	D	W	D	W
.01	2.0	.25	38.00	3.0	300.0
.02	4.0	.50	66.00	4.0	388.0
.04	7.5	1.00	100.0	5.0	455.0
.10	16.0	2.00	200.0	8.0	601.0

The efficiency as a waterway of a culvert of any size depends on the rapidity with which the water is carried away. This may be increased by so arranging the upper end that the water may enter

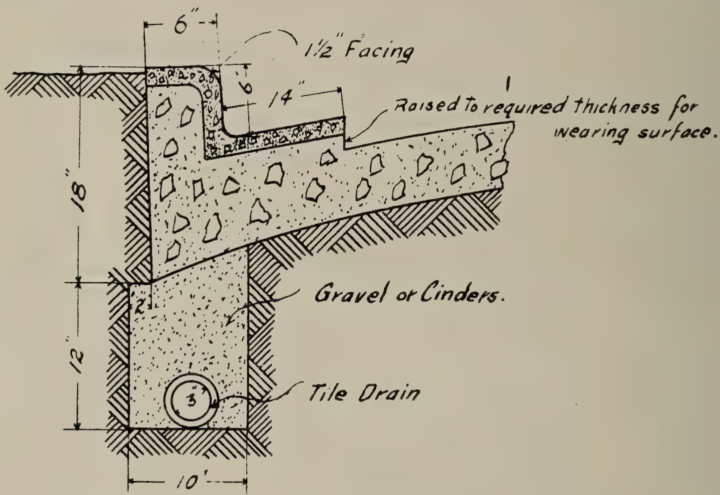

Fig. 3. Cross-section of a continuous Curb and Gutter

without retardation, and by increasing the inclination of its bed as much as the channel will allow. If constructed so that it may act under a head, the discharge will be greater, but this is impracticable for ordinary highway culverts.

Culverts should always, when practicable, be constructed at right angles to the direction of the road, Oblique structures are objectionable as being longer than if set at right angles, and also by reason of acute and obtuse-angled abutments and coverings neces-

sary. In every case, they should extend the full width of the road, and should be protected by strong guard rails at the ends.

The materials used in the construction of culverts are stone, brick, vitrified earthenware and concrete pipe, iron pipe and concrete. Wood should be avoided as much as possible because, though its first cost is small, it lasts only for a comparatively short time, and is liable to cause accidents through failure when the wood becomes decayed.

Concrete and vitrified earthenware pipe are very satisfactory where the flow is small. In many places one line of pipe is sufficient to cope with the water, but when larger areas are required, two small pipes laid side by side are preferable to one large one, since, to utilize the full capacity, the water need not rise so high in the former as in the single pipe.

When laying the pipes, care must be taken to have the bed rounded to conform with the proper depressions for sockets. The top surface of the pipe should not be less than eighteen inches below the surface of the road, and all joints should be carefully caulked to prevent water oozing through and washing out the bed. In all cases, the upper end or entrance should be protected by a masonry wall to prevent the water working in and around the pipe and washing it out. This wall should extend below the frost line to avoid heaving. The lower or discharging end of the pipe should be laid in such a position as to overcome the scouring action of back-water, and the pipe must have sufficient inclination to drain freely, since any freezing of water in the pipes is liable to burst them.

Iron pipe has, of late years, come into prominence for culvert construction. There are two kinds, the cast iron pipe and the corrugated galvanized iron pipe, both obtainable in all sizes up to six feet. Both are in general favor, the latter more so on account of its ease of transportation in knock-down form, and of erection into place by means of bolts. Iron pipes, however, have a great tendency to corrode under the action of water, and by reason of this, care must be taken in selection to secure a sufficient heavy gauge of metal free from impurities.

The process of laying such pipe is similar to that of concrete and earthenware pipes.

Stone and brick culverts are usually constructed in the form of an arch, and are provided with wing and apron walls on both ends.

For large and small culverts, nothing can excel concrete for endurance, efficiency and comparative ease of construction. It can be built in any form desired and almost any size. If properly placed, concrete requires little or no attention after construction, hence, practically no cost for maintenance.

Some of the forms adapted to concrete are circular (built with collapsible forms), box or rectangular, arched and I-beam construction. In excavating for concrete culverts, the footings should be carried to a solid bottom, and the apron walls should be carried to a sufficient depth to avoid any chance of water getting underneath the culvert.

Earth Roads

The term "earth road" is applied to that form of road in the construction of which earth alone is used. This class of road is probably the most common in country districts, and is, no doubt, the cheapest in first cost. Earth roads are at their best during the dry seasons, but with proper construction and maintenance may be considered good in any season.

The first step in the construction of an earth road is that of defining the centre line over which a system of levels should be taken. The problem of drainage should then be solved, for no road will endure that is not properly drained.

The work of construction should begin by ploughing up the surface and removing all sod from the roadway, it being undesirable because, though seemingly good material, the vegetable matter soon decays and forms, with the earth, a soft muck. The subsoil along the sides of the road should then be ploughed up parallel with the centre line, and the depth of the required ditches established. By means of a grader or scraper, it is thrown into the centre of the road, and worked into the required shape. It should then be finished off with a roller, until all hollows are filled and the work presents a smooth and even surface. When this is completed, the road is ready for traffic.

To keep the road in good condition is an easy matter, provided the right method is employed. When it shows signs of cutting into ruts, a split drag should be used. Greatest success will be achieved just after a rain, when the earth is soft, but not sticky enough to roll into clogs. The drag should be drawn up one side, and back the other until all ruts are filled. If holes have been made which are too deep to be filled by this method, earth of the same nature as that of which the road is made should be shovelled in, and tamped to an even surface. In no case should stones be used to fill up an earth road, as they will not wear off even with the rest of the road, and will form a hard ridge or a bumpy surface.

In the fall the road should be dragged to put it in good condition for winter. Gutters and ditches should be cleaned and culverts freed from rubbish. If this has been properly done, the road should be in a fair condition in the spring, when, under action of wind and sun, it will soon become hard and dry.

Sand roads are almost the opposite of earth and clay roads. They are at their best when wet. When dry, the sand has not sufficient stability in itself to sustain a load.

In constructing sand roads, the ditches and gutters should be made only large enough to carry away the rain water, as otherwise, they would have a tendency to dry out the road. Vegetation should be induced along the sides to conserve the moisture and to tend to prevent picking up of road material. Sand roads may also be improved by rolling, and it is possible by the addition of clay to the sand to make a road which, under moderate traffic and favorable conditions of climate, will be fairly serviceable.

Gravel Roads

Gravel roads are usually constructed on an earth foundation with gravel as the wearing surface. Gravel, unlike earth and sand, is not a simple material, but is a mixture composed of pebbles, broken fragments of rock, and sand or clay. Gravel for road-building must be carefully selected, so as to contain properly graded constituents. Too coarse a gravel will, undoubtedly, leave too many voids for entrance of water, thereby ruining the road; and again, gravel containing too much clay or sand makes a muddy road during wet weather, and is easily rutted even by moderate traffic. For best results in general, considering ordinary gravels, all stones that will not pass through a two and one-half inch mesh should be screened out. At least fifty per cent. by weight should consist of pebbles or fragments which will not pass through a one and one-quarter inch mesh; at least eighty per cent. should not pass through a one-half inch mesh, and the remainder should consist of small fragments of pebbles and sand from less than one-half inch in diameter to an impalpable powder. Although such gravel as this is very rarely or practically never found, it is offered as an ideal to be approached as nearly as possible.

In the construction of gravel roads, the bed is prepared with earth or clay shoulders at the sides leading to the gutters. The

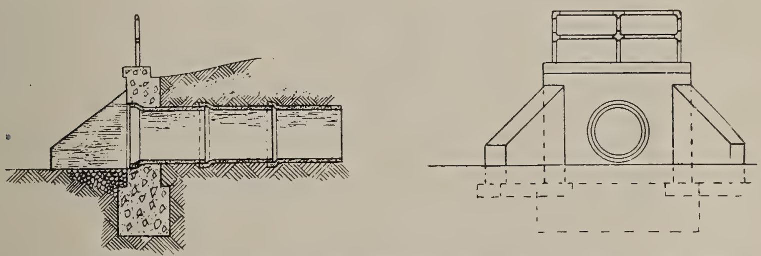

Fig. 4. Section and Elevation of the Concrete Head and Wing Walls protecting a Tile Culvert

subgrade should be well rolled, preferably with a steam roller, to the same crown as if desired on the finished road. The gravel should then be applied in thin layers, each layer being rolled before the next applied, until the required thickness of wearing surface is obtained. The process of consolidation will be aided by the addition of a little water. It should be continued until the pebbles cease to rise or creep in front of the roller. In applying the gravel, care should be taken to have a uniform mixture from top to bottom. Large stones, if placed in the bottom, have a tendency to rise under the action of frost, and vibration caused by traffic, and tend to disrupt the surface.

To maintain gravel roads, all that is necessary is to rake the loosened pebbles into the centre of the road where they can be consolidated by traffic. In the case of ruts and holes appearing, a thin

layer of gravel should be tamped in, and then another, and so on, till the even surface is restored. When great thicknesses of gravel are added at one time, the surface becomes compact, while the body is comparatively loose. This, under action of traffic and water, will soon destroy the road.

Macadam Roads

The process of macadamizing a road consists in compacting together, on a prepared subgrade, a number of layers of broken stone, which forms a surface to carry traffic. This form of pavement has been used to a great extent on main roads of travel in the country, and as a secondary paving in towns and cities. Macadam roads are suited to varying conditions. They have stability to withstand fairly heavy traffic, furnish good foothold for horses, and do not become slippery when wet. But the macadam road has one great objection, namely, it is very dusty in dry weather.

The qualities required in good road stone are toughness, hardness and ability to resist the disintegrating action of the weather. The fine dust made from powdering the stone should have more or less cementing action when mixed with water. Scrap rock forms a very durable and hard surface, but must be bound with limestone, dust, or some other agent. The stone should be uniform in quality, as otherwise, one place in the road will wear down quicker than another, thus forming holes and ruts to hold water, and assist in the destruction of the road surface.

The size of the stone depends, to a great extent, on the character of the rock. Hard rock should be broken finer than soft. It should be broken into pieces as nearly cubical as possible, since experiment shows that this shape binds best. When crusher broken, the stone should be screened by a rotary screen into grades as follows: dust, No. 1, ¼ to ½ inch; No. 2, ½ to 1 inch; No. 3, 1 to 2½ inches and tailings. The smaller the pieces used in the road, the smaller the percentage of voids, the more easily compacted and the smoother will be the surface of the finished road. The thickness of the wearing surface depends on the traffic, varying from six to twelve inches.

The essential points in the construction of a macadam road are:—

1. Proper drainage and rolling of the earth foundation.
2. The use of machine broken and screened stone.
3. Well sprinkled, but not over-flooded, with water.
4. Thorough consolidation with a steam roller.

The earth foundation should be carefully constructed, the subgrade thoroughly rolled until it presents a smooth and even appearance. Hollow places will gradually collect water, becoming soft and undermining the road. On this prepared subgrade, a layer of No. 3 stone and tailings should be spread, and thoroughly rolled. (When the subsoil has a tendency to be wet, a layer of large, flat stones may be laid in the bottom, forming what is known as a Telford foundation). A layer of grade No. 2 is then applied and rolled as

before. Then a layer of No. 1, sufficient to bring the surface to the desired crown, is added and rolled until the stones cease to creep before the roller. As it stands at this juncture, the road will contain from thirty-five to forty per cent. of voids. To fill these and also act as a binder, a coat of screenings is applied. This should be watered and rolled until a wave of grout passes along in front of the roller (brushing with large street brooms aids in working the grout into voids). At this stage, rolling should cease, and the road blocked to traffic for a sufficient time to allow the grout to set. In the last process care should be taken not to add too much screenings. They, when dry and ground to powder, form dust and mud when wet, and in frosty weather are likely to aid in the destruction of the pavement. A road constructed after this method is called a water-bound macadam, and is the kind in general use.

In many places at the present time, tar is being used as a binder. It eliminates the dust problem in dry weather, prevents the absorption of water which under action of frost disintegrates the macadam. It also serves to keep the aggregate together under the action of motor traffic. The methods of applying the tar to the stone are very numerous. Almost every company putting binders on the market has a different method of laying the pavement. The chief methods are: (1), penetration, where the binder is sprayed from a cart or applied with a hose under pressure, and (2) mixing the stone with the binder previous to laying. In both cases, the stone should be perfectly dry and the tar applied hot. The stone is laid in layers, and, as in the case of water-bound macadam, each layer is thoroughly rolled.

To maintain a macadam road in good condition, the surface should be kept free from any substance which will tend to make mud. In wheel tracks during heavy rains, will develop streams that soon wash out the binder. Loose stones, or any other substance which would cause any unusual impact, should be kept off the road. The use of water to lay dust should be limited. Traffic should be distributed over the entire surface. Free drainage should be provided at all times. In case of a rut or a hole appearing, the dirt should be cleaned out, the material in and around it loosened, and a sufficient quantity of new material added, so that when thoroughly tamped, the smooth surface will be maintained. If a considerable portion of the road is to be repaired, the old surface should be loosened up with a scarifier, graded off, new material applied and rolled down, as in the construction of a new road.

O. T. G. Williamson, '09, is engineer for the Canadian Stewart Co. at Princess Louise Embankment, Quebec.

Alan Fraser, '10, is assistant engineer with the Toronto Iron Works, Limited.

L. W. Klingner, '07, is resident engineer for the Crow Lake branch of the Canadian Pacific Railway.

W. O. Boswell, '11, has taken a position as electric-chemical engineer for the Tivani Electric Steel Co., of Belleville, Ont.

CLASS '13 GRADUATING DINNER

The Fourth Year held a final re-union as an undergraduate body on the evening of March 11th, in which eighty-four of its members participated. As guests, Dean Galbraith, Dr. Ellis, Professors Wright, Angus, Haultain, and Mr. Young were present. The evening's proceedings were well interspersed with a variety of entertainment. Mr. Blain furnished several violin solos and showed his ability as a trifler upon the strings to be of no small calibre. Mr. Goodman recited Drummond's "Stove-pipe Hole" in the precise manner the author would have prescribed, and Mr. Holden's exemplification of "Casey at the Bat" was likewise delivered as superbly as superbness may be applied to humor.

Dean Galbraith made a very hearty response to a toast proposed to him by Mr. Black. He referred to the building-up process which the School had undergone since its inception. He emphasized the need, among other things, of the curriculum undergoing a pruning operation. He felt that the lengthy list of subjects taught should be curtailed, as superfluity of instruction prevented, in a measure, the proper treatment of the most important parts of the course.

The toast to the Faculty, proposed by Mr. Rous, was replied to by a number of the members of the class, their remarks bearing largely upon the pleasant associations between staff and students during the past years, and a hope that the end of the undergraduate trail did not mean a severance of the many friendship ties formed within that time.

"The Future"

Professor Haultain responded to Mr. Mutch's toast, "The Future." His remarks summed up the chief requirement of the future in an evolutive review of the past.

"The whole existence of mankind is generally assumed to have lasted not less than 240,000 years. It may have lasted much longer, it cannot have lasted less. If this period be represented by a day of twelve hours, then each hour would represent 20,000 years, each minute 833 years. If we imagine that we of the present are living at noon on that protracted day the startling fact comes out *that for over eleven and a half hours there is nothing to record.* At twenty minutes before twelve the earliest vestiges of Egyptian and Babylonian civilization begin to appear. Greek literature is seven minutes old. At one minute before twelve the Advancement of Learning makes its appearance. The steam engine is only half a minute old.[1]

"Yes, the engineer as we know him is only a matter of a few seconds. That is a long back-sight and if this story of the geologists is true, what was happening during those eleven and a half hours? and what sort of a line does it give us for the future? No doubt if our sight were clear we could read here much of the riddle

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1 John Adams: The Evolution of Educational Theory, p. 86.

of existence. Though little apparently has been recorded, much was accomplished during that quarter of a million years, Very enduring foundations were being laid, very definite trails were travelled, and it may be taken as an axiom that the earlier the foundation, provided that it has survived, the more enduring is it to-day. What more surprisingly constant than our blood temperature of normal health? With no other reason than their ancient origin, how persistent are some of the likes and dislikes; tendencies that are called instincts, our disgust at the smell of putrefaction, our delight at fresh rain on dry earth, our instinctive following of a leader. Everybody, old and young, black, yellow, and white, likes the open fire. It was the first luxury of our own commanding. For long it was almost our only luxury. It may have been that it was for the sake of the fire that we left the tree tops.

"The beginnings of the foundations of our modern civilization go back a long way. Organized co-operation and language are at the base of things. Organization we had without language—that came with the fighting animal. Language grew at the fireside; grew for and with the story-teller. As the luxury of our fire brought us to our feet and set our backbone upright, so story telling led us by psychic ways still further from the mere animal. The physical champion was the great man of the tribe, but the story teller was the advanced man and was a leader in all things other than war. Later he became a scriber on bone, a teller of stories in picture. Mimicry and song had helped his meagre language, and thus we find the story teller laying the foundations of all that we understand by art, wherein we are to-day furthest removed, in our activities, from the animal. The story teller has been in the vanguard of all progress since the beginning. The story teller to-day commands the attention of the tribe and of the individual as nothing else. The physical champion without the story is but little. It is the moving picture rights that bring the money. Roosevelt received $350,000 for his services for seven years as president of the United States, but he received a million for the story of his African holiday.

"The story draws and holds as does the fire. Without the hearth there is no home, and without the story there is no hero. This is one of the trails that has been trodden since first we had a trail. A psychic trail it is, a nerve path but none the less definite. Man now treads unconsciously but surely this much trodden trail of two hundred thousand years. We engineers, we of the last few seconds, are so busy with our work that we think we have not time to tell the story, much less time to learn how to tell it. And our trail is so new, pushed ahead so far and so rapidly, that the professional story teller is left behind; he can neither follow nor understand. We achieve, but the story is lacking, and the public does not recognize the greatness of the achievement. Gentlemen, you are going out into the finest work of the world, the finest opportunities for your activities that have ever presented themselves to the young man. The engineer is doing the world's work to-day, but he is not recognized nor paid accordingly. We must learn to

FOURTH YEAR EXECUTIVE, 1912–13.

Standing: R. L. HEARN, Sec'y-Treas.; G. J. MICKLER, Rep. Mech. and Elect.; W. K. THOMPSON, Rep. Chem. and Mining; D. BLAIN, Rep. Civils and Arch.
Seated: H. A. HAWLEY, President; DEAN GALBRAITH, Honorary President; B. S. BLACK, Vice-President.

tell our own story. And remember—the story teller is not merely the translator of events into words or pictures. He is a keen student of man, of the peculiarities and needs of the listener, because a story is not really a story without the interest of the listener. What the engineer needs more than anything else to-day and to-morrow is something of the art of the story teller. Without the story our achievements are nought: we are merely hewers of wood and drawers of water."

The Average Man

Mr. C. R. Young's congratulatory remarks to the year contained special emphasis on the place of the average man in engineering. Paradoxical though it might seem, the average man very frequently out-distanced his brilliant competitor in life's work as a result of certain qualifications of a modest, and perhaps of an almost commonplace, character. His better appreciation of relative values, his business sense, his balance and normality, brought him into positions of trust and large responsibility, while the man of outstanding ability often confined himself to narrow fields of special investigation, little known and less appreciated by the employers of engineers. The average man derived success, too, from his ability to get along with others—a rare qualification of the genius. Friendly intercourse and pleasant relationships between men were, the speaker held, an asset of very great value to the engineer.

Another factor which he claimed to belong to the ultimate triumph of the average man was the fact that he carried a greater reserve of energy than the man of spectacular attainments. When the latter, through extraordinary labors and disregard for Nature's limitations, had worn himself out, the man of no future moved steadily onward and carried vast enterprises to successful completion.

The Electrolytic Cell

Dr. Ellis, when called upon for a few remarks, spoke of the School, and in the following estimable manner:

"This School is a great electrolytic cell—a contrivance for transmitting intellectual energy to supply the needs of the world. Some of this intellectual energy, like coal, has been stored up during the ages of the past, and must be obtained by digging and delving among the deposits of bygone learning. Some, like flowing water, is pulsating with the life and movements of the past.

"In this cell we, the teachers, are the anodes. Whether we be of expensive platinum or of cheap retort carbon, our function is the same, to collect this energy brought to us by cables of many kinds, by books, by journals, by conversation, by experience—to bring it into the cell and to give it up to the ions—to you, the students, whose function it is to carry each his own charge of intellectual energy to the cathode, to the place where it is wanted, to the negative electrode representing, as I have said, the needs of the world. Your capacities for carrying intellectual energy are not all the same. Some are mono-valent, some di-valent and some poly-valent. It is

enough if each of you carries his proper charge—he can do no more, and he ought to do no less.

"You carry your charge to the cathode and you give it up, and take your place in the world as free elements, some as polished silver, some as brilliant copper, some as useful nickel and some, possibly, as bubbles of gas.

"But what about those ions whose charge of intellectual energy is negative? They go back to the anodes and are removed from the cell.

"Experience has discovered an interesting law with regard to these negative ions. The number of them discharged from the cell varies inversely as the square of the time. If there are twenty of them in the first year there will be five in the second year, 2.2 in the third year, and only 1.25 in the fourth year.

"I am sure, gentlemen, that those negative ions are not with us here to-night. They are either at home vainly trying to crowd a tri-valent charge on a mono-valent ion, or they are elsewhere taking part in secondary reactions tending to impair the efficiency of the cell."

An important part of the proceedings, the election of officers for the next three years, resulted in Mr. E. R. Gray as president, and Mr. C. C. Rous as secretary-treasurer. The executive committee consists of the following men in addition: Messrs. R. L. Hearn, civils; W. K. Thompson, miners; F. R. Sims, mechanicals; F. W. Beatty, railways; H. D. Livingston, architects; and H. L. Seymour, for the sanitary engineers. The executive has already assumed its duties to the extent of calling the attention of the class to essential points in its organization proceedings. A careful compilation of the home and business addresses of each member, together with his occupation and other interesting news regarding him is in preparation, and a class fee of $1.00 for the next three years has been arranged to defray the expenses which the next reunion will incur. The enthusiastic manner in which the class as a whole is launching itself as a graduate organization is worthy of compliment and the old adage concerning things well begun comes to mind. APPLIED SCIENCE wishes the class great success, not only in its organization, but in the professional welfare of its individual members.

G. H. Wilkes, '11, is with the Massey-Harris Co., Toronto, as draftsman.

G. Kribs, '05, is chief engineer of the Texas Power and Light Co., at Dallas, Texas.

TREASURER'S REPORT

Owing to the pressure of examinations throughout the month of April, and also to the fact that a number of accounts have not, as yet, been received, the final report of the treasurer for the financial year of the Society ending March 31st, 1913, has not been presented. It will be published in the May number of this journal.

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EDITORIAL

THE NEW DEGREE

The Calendar for 1913-14 has been out for several weeks. Its earlier appearance makes it much more useful to the undergraduates, who can better equip themselves with an idea of their next year's work, while they are still at hand to discuss it with each other and with members of the staff. Every year the Calendar is an indication of the activities at the School, and gives in plain facts the improvements which the year has brought to the curriculum. The 1912-13 calendar announced the addition of a new department, that of Metallurgical Engineering, prepared to provide instruction throughout the four years to those students desiring to enter that branch of the profession, the academic work before graduation to be supplemented by at least eight months' experience in metallurgical work.

This year a new degree has been announced. A graduate

who has attained the degree of Bachelor of Applied Science (B.A.Sc.), may spend an additional year in attendance as a student in the Faculty of Applied Science and pass an examination and prepare a thesis upon a course of study approved by the Council, and thus be eligible for the degree of Master of Applied Science (M.A.Sc.)

A new degree has been the subject of discussion for some time in the Faculty Council and in the Senate Chamber of the University, and its establishment at this time marks an important advancement in the Faculty of Applied Science. In all probability many graduates who have had the benefit of several years in the pursuit of various branches of the profession, and who feel a need of further study and instruction in some special branch, will avail themselves of this long felt want, now at their disposal.

HIGHWAY ENGINEERING

If the subject of a fourth year man's thesis is an indication of the branch of engineering in which he is most interested, highway construction and maintenance is an exceedingly popular branch among those who have gone up for the degree of B.A.Sc. during the past several years. The percentage of men specializing in this work during the fourth year is increasing in accordance with the development of the popular good roads movement in Canada and the United States. The engineer is rightly busying himself in the cause of better thoroughfares. Being specially fitted for the work he should apply his capabilities toward improving existing roads and constructing new ones. He will thus enhance to an interesting degree in the community the profession which he follows.

Frequently an engineer is criticized because he remains aloof from discussions affecting municipalities in general. To him such considerations may at times appear to be matters beyond the horizon of his work. Highway improvement, however, is a subject before municipal associations and similar bodies into which the engineer should enter without hesitation. The public needs and will welcome his advice and co-operation. The construction of a good road is a problem for the engineer.

In the civil engineering course in the Faculty of Applied Science the fourth year men are afforded a lecture and laboratory course of about eight hours per week, dealing with the design and construction of highways and pavements, and with the study and testing of various materials used in such work. The course is associated with a similar course in sanitary engineering, as one of the options of the final year. The work in highway engineering has been in charge of Mr. A. T. Laing, B.A.Sc. This week Mr. Laing goes to Europe, where he will study the roads of England, France, Italy and other countries, and will also attend the International Road Congress to be held in London, June 23rd to 28th. The information and road data which will be accumulated during this investigation will be an added asset to the course, which, as one of the youngest in the Faculty, is already making a fine showing.

THE ANNUAL ELECTIONS

This yearly event was marked with the usual enthusiasm and few are the events in the college year that equal it in importance. Candidates did not enter the field as early as usual and very little excitement prevaded the atmosphere of the studious month of March until the appearance of the election daily, the "Toike Oike," on the morning of the day of nominations. This is the third year for the publication and, given over entirely to the policies, platforms, qualifications and advertising data of the would-be office holders, it very efficiently fulfilled its purpose. It appeared at eleven a.m. on the Wednesday, Thursday and Friday of election week, filled to the farthest corner with anticipation and advertising. Mr. N. L. Somers, '14, and Mr. G. G. Macdonald, '15, were the editors this

F. C. MECHIN
President of the Engineering Society, 1913-14

year, with Mr. J. A. P. Marshall, '14, and Mr. W. S. Steel, '15, as associates. They are to be congratulated upon the paper, neat in appearance, impartial in its editorial policy, prompt in distribution, and successful as a venture.

The presidential chair was contended for by Messrs. F. C. Mechin and G. M. Smythe. The latter entered the contest upon nomination day, which typifies, generally, the spontaneous action common among many of the candidates. The offices, however, were exceptionally well contested, and the shortening to several days of the election fever did not detract from the general excitement

of the occasion, but rather stimulated the candidates and their supporters with promptness and alacrity in covering the entire filed.

The voting was divided between afternoon and evening sessions. The examination hall afforded an excellent accommodation for the evening's sports and final reckoning. Wrestling, boxing, roller hockey, etc., formed a programme of amusements, while the Toike Orchestra furnished a good musical programme throughout the entire evening. One of the important events among the former was a chariot race which will long be remembered for its uniqueness and for its close finish, taxing the capabilities of the judges to the elastic limit. The returns were completed before eleven o'clock and as the sports had continued uninterrupted until that time, a great deal of credit must be given to Mr. W. T. Curtis for his excellent floor management. The results of the voting is as follows:—

President, F. C. Mechin.

1st vice-president, F. S. Rutherford.

2nd vice-presidents—civils, R. E. Laidlaw; mechanicals and electricals, K. A. Jefferson; miners and chemists, C. K. Macpherson (accl.)

4th Year representative, R. G. Matthews.
3rd Year representative, W. R. McGie.
2nd Year representative, H. B. Little.
1st Year representative (to be elected).
Corresponding-secretary, A. W. Sime.
Treasurer, W. G. Millar.
Recording-secretary, N. R. Adams.
Curator, C. Smythe.
Jun. Varsity representative, J. F. Young.
Senior Varsity representative, G. J. Mullins (accl.)

C. F. Szammers, '11, has gone to Hudson Bay as assistant to J. G. McMillan, '00, who has charge of the harbor and river survey work for the Ontario Government.

H. O. Hill, '07, until recently with the Riter-Conley Mfg. Co., has accepted a position with the Blaw Steel Construction Co., of Pittsburg. Mr. F. M. Bowman, '90, is vice-president of this company, and head of the structural department. Their new structural plant, with a capacity of 50,000 tons of fabricated steel per year, is near completion at Hoboken, Pa.

F. V. Seibert, '09, is carrying on a surveying and engineering practice in Regina and Edmonton.

J. W. R. Taylor, '08, is erecting engineer for the Canadian Westinghouse Co., Hamilton.

J. C. Murton, '10, is resident engineer for the city of Moose Jaw, in charge of the construction of a dam for a high pressure supply in connection with the city's fire system.

A. B. Mitchell, '08, is in Montreal, employed with N. McLeod & Co., on the city's harbor development.

DIRECTORY OF THE ALUMNI

This department began in November, 1912, and the entire list of graduates will be reviewed before the end of the year.

A number of corrections have been received bearing upon the part of the directory which has already been published, and our list of addresses is thus becoming more authoritative. If those whose names will appear during the next several months will assure themselves that our record of their location and employment is correct before publication, it will be improved still more, as there are some addresses upon our files that are long standing and hardly to be depended upon.

D (*Continued*)

Dunlop, R. J., '02, is a member of the National Refining Co., dealers in dental supplies, Toronto.

Dunn, T. H., '93, is at Winchester, Ont., in civil engineering and land surveying.

Duthie, L. J., '09, is surveyor and assayer for the McEnhanney Mines, Porcupine, Ont.

Dyer, F. C., '08, is demonstrator in mining, University of Toronto.

E

Eagleson, F. M., '08, is engaged in civil engineering, surveying, and municipal work at Winchester, Ont.

Eason, D. E., '01, is division engineer on the construction of the Trent Valley Canal, at Peterborough, Ont.

Eckert, C. H., '11, is with the Standard Chemical Co., at Longford, Ont., as chemist.

Edwards, W. M., '02, is a member of the firm of Duff & Edwards, engineers and surveyors, Lethbridge, Alta.

Edwards, C., '08, is with the Standard Chemical Co., Toronto.

Elliott, C. F., '11, is enrolled at Osgoode Hall, supplementing his engineering course with one in law.

Elliott, G. R., '11, is with the Department of the Interior at Calgary, on irrigation work.

Elliott, H. P., '96, is a consulting engineer with offices in London and Toronto.

Elliott, J. A., '11, is engaged as chemist with the Castner Electrolytic Alkali Co., of Niagara Falls, N.Y.

Elliott, J. C., '99, whose home is at Kelso, Ont., has no other address with us.

Elder, A. J., '04, is with the Department of the Interior, at Ottawa, in the Topographical Surveys Branch.

Elwell, W., '02, deceased Sept. 3rd, '09.

Emery, V. H., '10, is at the McIntyre Mines, Porcupine, Ont., as assistant engineer.

Empey, J. M., '02, is with the Department of Public Works, Calgary, as district engineer and surveyor.

English, A. B., '90 (deceased).

Evans, S. D., '07, has no other address than his home at Leamington, Ont., upon our lists.

Evans, S. L., '08, has Corinth, Ont., for his home address. We have no record of his professional work.

Evans, W. J., '10, is in the employ of the Canadian Westinghouse Co. at Hamilton, Ont.

Ewart, J. A., '94, resides in Ottawa, Ont., where he has an architectural practice.

Ewart, F. R., '07, is in Toronto, with the Toronto Hydro Electric System.

Ewing, E. O., '08, is in Toronto. He is engaged in surveying and structural engineering.

F

Fairburn, J. M. R., '93, is with the Canadian Pacific Railway as assistant engineer, located in Montreal.

Fairchild, C, '92, is connected with the Dominion Government, Department of the Interior. His home is in Brantford, Ont.

Fairlie, H. W., '10, is in the employ of the Northern Electric & Mfg. Co., Montreal, as sales engineer.

Falconer, F. S., '09, is with the topographical survey branch, Department of the Interior, Ottawa.

Fargey, T. A., '09, is electrical engineer for the Scott Bros. Electric Co., Detroit, Mich.

Farrell, K. A., '11, is assistant engineer with Speight & Van Nostrand, Toronto.

Farelly, T. J., '11, is with the Bell Telephone Co., Montreal, in the transmission department.

Fear, S. L., '06, is in charge of the gas engine department of the Canada Foundry Co., Toronto.

Fensom, C. J., '03, is conducting a consulting practice in mechanical engineering, Toronto.

Ferguson, G. H., '05, is assistant engineer to the Commission of Conservation, Canada.

Ferguson, J. B., '09, was in Chicago when last heard from. We have no address for him at present.

Ferguson, J. W., '10, until recently with the Dominion Bridge Co., Montreal, is now in Toronto.

Ferguson, A. T., '09, is a member of the firm of G. T. Fergusson & Co., stock brokers, Toronto.

Fierheller, H. S., '05, deceased, June, 1910.

Fingland, W., '93, is engaged in architecture. His office is in Winnipeg, Man.

Fisken, J. B. K., '10, is a demonstrator in the department of architecture, University of Toronto.

Flanagan, O. L., '08, is resident engineer on the Prince Albert hydroelectric development at Prince Albert, Sask., for C. H. & P. H. Mitchell, Toronto.

Fleck, J. G., '04, is a member of the firm of Fleck Bros., Vancouver, B.C.

Fleming, G. R., S., '07, is with Atwell Fleming Printing Co., as superintendent.

Fletcher, A. W., '10, is in Calgary, Alta., with the Department of Public Works.

Fletcher, F. L., '10, is also on the staff of the Department of Public Works, Calgary.

Fletcher, J. A., '10, is with E. W. Robinson, D.L.S., Fisher River, Man., as assistant.

Flint, C., '08, is in the employ of the Canadian Pacific Railway on lines west of Winnipeg.

Flint, T. R. C., '10, has just completed a post-graduate course in engineering, University of Toronto.

Flook, S. E., '11, whose home is in Willowdale, Ont., is in the employ of W. S. Gibson, '04, surveyor.

Flynn, C. C., '11, is in Chicago, with the Western Electric Co., Limited.

Follett, R. C., '10, has no address upon our records except his home address, Oakville, Ont.

Forbes, D. L. H., '02, is a consulting mining and metallurgical engineer with offices in Toronto.

Ford, A. L., '04, is government inspector and engineer, Department of Railways and Canals, at Prince Rupert, B.C.

Foreman, J. M., '10, whose home is in Lucan, Ont., has no business address with us.

Forman, W. E., '99, was in Pittsburg, with the Westinghouse Electric & Mfg. Co., construction department, when last heard from.

Forrester, C., '93, had Indian Head, Sask., as his address until recently. We do not know his present address.

Forward, E. A., '97, is engineer in charge of St. Andrew's lock and dam at Lockport, Man.

Forward, C. C., '06, is assistant analyst, Department of Inland Revenue laboratories, Ottawa.

Foster, A. H., '08, is manager of the Guelph Radial Railway Co. and Guelph Waterworks, Guelph, Ont.